MISB MOTION IMAGERY STANDARDS BOARD	MISB ST 0605.8
STANDARD	
Class 0 Motion Imagery, Audio and Metadata over SDI	**5 October 2017**

1 Scope

This standard provides guidance for carrying Class 0 Motion Imagery and KLV metadata over Serial Digital Interface (SDI).

This standard provides for inclusion of Absolute Time as either a microsecond-resolution Precision Time Stamp, or a nanosecond-resolution Nano Precision Time Stamp as defined in MISB ST 0603.

This standard defines a Precision Time Stamp Pack, which is a KLV construct consisting of a Time Status byte and a Precision Time Stamp. To support the Nano Precision Time Stamp, this standard defines a Nano Precision Time Stamp Pack, which is a KLV construct consisting of a Time Status byte and a Nano Precision Time Stamp. In addition, the placement of these timestamp KLV packs and other KLV metadata within the ancillary (ANC) data space allocated in SMPTE-defined image formats is specified.

The standard identifies the ANC packet format for encoding KLV metadata into the ancillary data space.

SMPTE standards required for inserting audio into SDI are indicated.

Finally, informative guidance on data capacities for various SDI standards is provided.

2 References

[1] MISB ST 1603.2 Time Transfer Pack, Oct 2017.

[2] MISB ST 0603.5 MISP Time System and Timestamps, Oct 2017.

[3] MISB MISP-2018.1 Motion Imagery Standards Profile, Oct 2017.

[4] MISB ST 0807.20 MISB KLV Metadata Registry, Oct 2017.

[5] SMPTE RP 168:2009 Definition of Vertical Interval Switching Point for Synchronous Video Switching.

[6] SMPTE RP 214:2002 Packing KLV Encoded Metadata and Data Essence into SMPTE 291M Ancillary Data Packets.

[7] SMPTE ST 291-1:2011 Television - Ancillary Data Packet and Space Formatting.

[8] SMPTE ST 12-2:2014 Television - Transmission of Tme Code in the Ancillary Space.

[9] SMPTE ST 424:2012 3 Gb/s Signal/Data Serial Interface.

[10] SMPTE ST 425-1:2014 Source Image Format and Ancillary Data Mapping for the 3 Gb/s Serial Interface.

[11] SMPTE ST 352:2013 Television - Video Payload Identification for Digital Interfaces.

[12] SMPTE ST 299-1:2009 Television - 24-Bit Digital Audio Format for SMPTE 292 Bit-Serial Interface.

[13] SMPTE ST 299-2:2010 Television - Extension of the 24-Bit Digital Audio Format to 32 Channels for 3 Gb/s Bit-Serial Interfaces.

[14] SMPTE ST 355:2001 Television - Format for Non-PCM Audio and Data in AES3 - KLV Data Type.

[15] SMPTE ST 337:2015 Television - Format for Non-PCM Audio and Data in an AES3 Serial Digital Audio Interface.

[16] SMPTE ST 339:2015 Television - Format for Non-PCM Audio and Data in AES3 - Generic Data Types.

[17] SMPTE ST 267:1995 Television - Bit-Parallel Digital Interface - Component Video Signal 4:2:2 16x9 Aspect Ratio.

[18] SMPTE ST 294:2001 Television - 720x483 Active Line at 59.94-Hz Progressive Scan Production –Bit-Serial Interfaces.

[19] SMPTE ST 259:2008 Television - SDTV Digital Signal/Data - Serial Digital Interface.

[20] SMPTE ST 293:2003 Television - 720x483 Active Line at 59.94-Hz Progressive Scan Production – Digital Representation.

[21] SMPTE ST 349:2001 Television - Transport of Alternate Source Image Formats though SMPTE 292M.

[22] SMPTE ST 292-1:2012 1.5 Gb/s Signal/Data Serial Interface.

[23] ITU-R BT.1358-1 (09/2007) Studio Parameters of 625 and 525 Line Progressive Television.

[24] SMPTE ST 296:2012 1280 x 720 Progressive Image 4:2:2 and 4:4:4 Sample Structure - Analog and Digital Representation and Analog Interface.

[25] SMPTE ST 274:2008 Television - 1920 x 1080 Image Sample Structure, Digital Representation and Digital Timing Reference Sequence for Multiple Picture Rates.

[26] SMPTE ST 435-1:2012 10 Gb/s Serial/Data Interface - Part 1: Basic Stream Distribution.

[27] SMPTE ST 2036-1:2014 Ultra High Definition Television - Image Parameter Values for Program Production.

[28] SMPTE ST 435-2:2012 10 Gb/s Serial Signal/Data Interface - Part 2: 10.692 Gb/s Stream - Basic Stream Data Mapping.

[29] SMPTE ST 2036-3:2015 Ultra High Definition Television - Mapping into Single-link or Multi-link 10 Gb/s Serial/Data Interface.

[30] SMPTE ST 2082-10:2015 2160-line Source Image and Ancillary Data Mapping for 12G-SDI.

[31] SMPTE ST 2081-11:2016 2160-Line Source Image and Ancillary Data Mapping for Dual-Link 6G-SDI.

[32] SMPTE ST 425-5:2014 Image Format and Ancillary Data Mapping for the Quad Link 3 Gb/s Serial Interface.

3 Revision History

Revision	Date	Summary of Changes
0605.8	10/5/2017	• Added support for the Nano Precision Time Stamp • Nomenclature change: Precision Time Stamp Status to Time Status; aligns with generic usage of timestamps for Absolute Time defined in ST 0603 • Deprecated REQs: -10, -19 • Added REQ's: -20 through -26 • Updated references

4 Acronyms

AFD Ancillary Data Flag
ANC Ancillary Data Space
DC Data Count
DID Data ID
HANC Horizontal Ancillary Data Space
KLV Key Length Value
MID Message ID
MISB Motion Imagery Standards Board
MISP Motion Imagery Standards Profile
PSC Packet Sequence Count
SDI Serial Digital Interface
SDID Secondary Data ID
SMPTE Society of Motion Picture and Television Engineers
PSC Packet Sequence Count
TRS Timing Reference Signal
UDW User Data Word
VANC Vertical Ancillary Data Space

5 Definitions

3G-SDI 2.97 Giga-bits per second serial digital interface
6G-SDI 5.94 Giga-bits per second serial digital interface
12G-SDI 11.88 Giga-bits per second serial digital interface
480p Line-progressive Enhanced Definition (ED) format of the 525-line Standard Definition (SD) system
576p Line-progressive Enhanced Definition (ED) format of the 625-line Standard Definition (SD) system

720p	High Definition (HD) 1280 x 720 format, progressive scan
1080p	High Definition (HD) 1920 x 1080 format, progressive scan
2160p	Ultra-High Definition (UHD-1) 3840 x 2160 format, progressive scan

6 Introduction

This document assumes use of image sampling formats prescribed by SMPTE for the commercial broadcast industry, specified as an active image area surrounded by vertical and horizontal non-image blanking regions. Within these regions non-image data can be placed, and a specific image sampling format defines the quantity of space available. Data is encapsulated in ANC (ancillary) packets, which affords a generic wrapper for various types of data. The ANC packet provides a natural carrier for non-image data across a Serial Digital Interface.

Serial Digital Interface (SDI) – developed by SMPTE – is a family of interfaces standardized to accommodate various image formats. The ANC packet developed by SMPTE is designed to encapsulate – among other data types – metadata and audio for transport over SDI within the non-image data space of an image. Two non-image data spaces are defined: the HANC, or horizontal ANC data space, which corresponds to the horizontal blanking interval, and the VANC, or vertical ANC data space, which corresponds to the vertical blanking interval.

This document provides guidance on encoding KLV metadata into ANC packets for carriage within the VANC of Class 0 Motion Imagery (non-compressed), specifically to include, either a Precision Time Stamp or a Nano Precision Time Stamp, a Commercial Time Stamp, and other metadata all encoded as KLV (Key Length Value). Introduced in MISB ST 1603 [1] is a Time Quality Local Set to qualify the relationship between a receptor clock and its reference clock with status information. The Time Transfer Local Set provides far greater information than the Time Status as defined in MISB ST 0603 [2], and is recommended to be included if needed in applications.

The Horizontal Ancillary Data Space (HANC), which is generally reserved for carrying audio, can optionally be used for additional metadata once the VANC is exhausted.

7 Timestamps based on Absolute Time

The MISP [3] mandates all Motion Imagery contain a timestamp which is based on Absolute Time governed by the MISP Time System defined in MISB ST 0603. Two KLV pack constructs provide for either a microsecond resolution (Precision Time Stamp) or a nanosecond resolution (Nano Precision Time Stamp) count of Absolute Time. Application requirements for time resolution will determine which timestamp to use.

The MISP also mandates only one type of timestamp is allowed within an instantiation of Motion Imagery. This will prevent confusion as to which timestamp is valid.

8 Precision Time Stamp Pack

The construction of the Precision Time Stamp Pack (shown in Figure 1) includes a Pack Key, its Length and a Value, where the timestamp information is encoded.

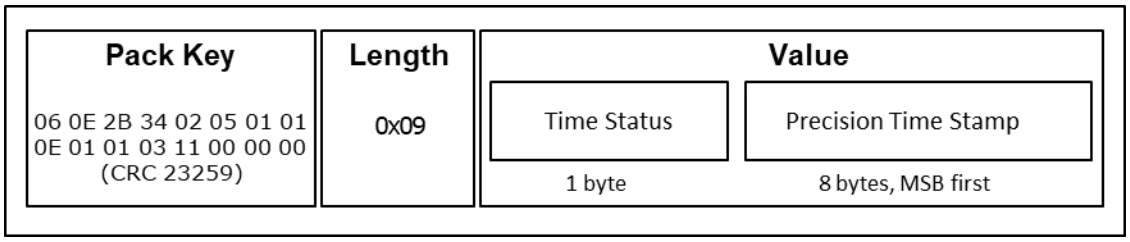

Figure 1: Precision Time Stamp Pack

The Pack key for the Precision Time Stamp is registered in MISB ST 0807 [4] as:

06.0E.2B.34.02.05.01.01.0E.01.01.03.11.00.00.00 (CRC 23259)

The Length of the pack is 0x09 (9 bytes).

The Value in the pack contains two subfields:

1) A one-byte Time Status, which indicates the state of the source time reference (as defined in MISB ST 0603).
2) A uint64 (8-byte) Precision Time Stamp (as defined in MISB ST 0603).

8.1 Time Status

The Time Status provides information about the timing source reference. See MISB ST 0603 for the definition of this value.

8.2 Precision Time Stamp

The Precision Time Stamp is a microsecond-resolution, 8-byte value as specified in MISB ST 0603. The Precision Time Stamp follows the Time Status value in the pack. Table 1 shows the byte ordering of the Precision Time Stamp, where Byte 1 is the most significant byte.

Table 1: Byte Assignment for 64-bit Precision Time Stamp

Bytes 1, 2	Byte 1 and 2 (Most significant bytes) of Precision Time Stamp
Bytes 3, 4	Byte 3 and 4 of Precision Time Stamp
Bytes 5, 6	Byte 5 and 6 of Precision Time Stamp
Bytes 7, 8	Byte 7 and 8 (Least significant bytes) of Precision Time Stamp

The following requirements define the construction rules for the Precision Time Stamp Pack:

Requirement(s)	
ST 0605.4-07	The Precision Time Stamp Pack shall contain the Length (in hex) 0x09.
ST 0605.4-08	The Precision Time Stamp Pack shall contain the Time Status value.
ST 0605.4-09	The Precision Time Stamp Pack shall contain the Precision Time Stamp.

9 Nano Precision Time Stamp Pack

The construction of the Nano Precision Time Stamp Pack (shown in Figure 2) includes a Pack Key, its Length and a Value, where the timestamp information is encoded.

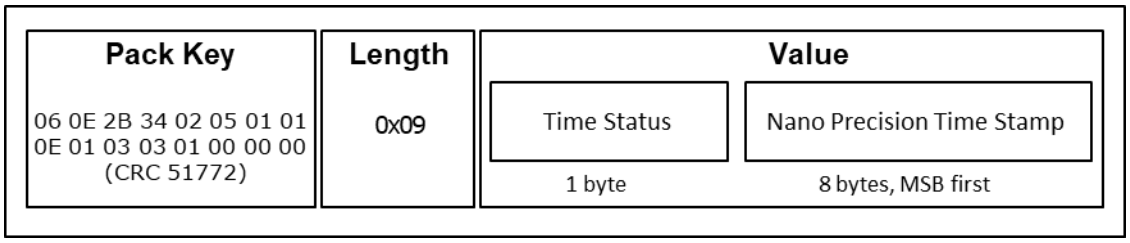

Figure 2: Nano Precision Time Stamp Pack

The Pack key for the Nano Precision Time Stamp is registered in MISB ST 0807 as:

06.0E.2B.34.02.05.01.01.0E.01.03.03.01.00.00.00 (CRC 51772)

The Length of the pack is 0x09 (9 bytes).

The Value in the pack contains two subfields:

3) A one-byte Time Status, which indicates the state of the source time reference (as defined in MISB ST 0603).
4) A uint64 (8-byte) Nano Precision Time Stamp (as defined in MISB ST 0603).

9.1 Time Status

The Time Status provides information about the timing source reference. See MISB ST 0603 for the definition of this value.

9.2 Nano Precision Time Stamp

The Nano Precision Time Stamp is a nanosecond-resolution, 8-byte value as specified in MISB ST 0603. The Nano Precision Time Stamp follows the Time Status value in the pack. Table 2 shows the byte ordering of the Nano Precision Time Stamp, where Byte 1 is the most significant byte.

Table 2: Byte Assignment for 64-bit Nano Precision Time Stamp

Bytes 1, 2	Byte 1 and 2 (Most significant bytes) of Nano Precision Time Stamp
Bytes 3, 4	Byte 3 and 4 of Nano Precision Time Stamp
Bytes 5, 6	Byte 5 and 6 of Nano Precision Time Stamp
Bytes 7, 8	Byte 7 and 8 (Least significant bytes) of Nano Precision Time Stamp

The following requirements define the construction rules for the Nano Precision Time Stamp Pack:

Requirement(s)	
ST 0605.8-20	The Nano Precision Time Stamp Pack shall contain the Length (in hex) 0x09.
ST 0605.8-21	The Nano Precision Time Stamp Pack shall contain the Time Status value.
ST 0605.8-22	The Nano Precision Time Stamp Pack shall contain the Nano Precision Time Stamp.

10 Class 0 Motion Imagery

The guidance in this document specifically applies to the set of Class 0 Motion Imagery formats defined by SMPTE standards for enhanced, high and ultra-high definition found in broadcast television. The specific image characteristics for these image formats are further identified in the MISP [3].

10.1 Image Format

SMPTE image formats share a common structure as shown in Figure 3. Discussion is based on one image, or frame of Motion Imagery.

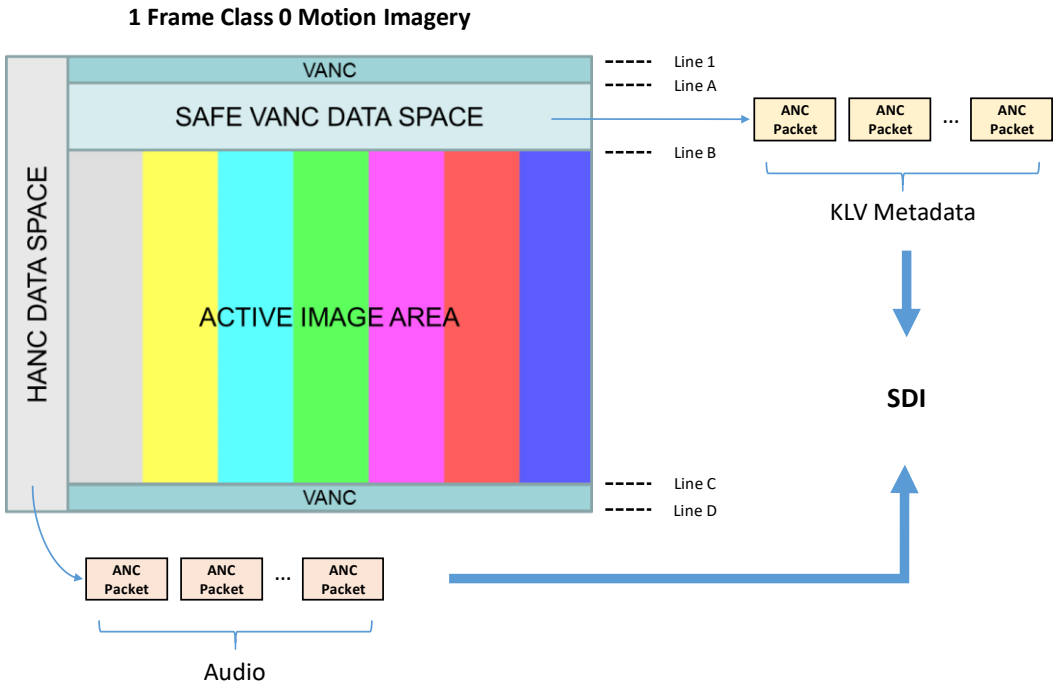

Figure 3: General SMPTE Image Format

Three "data areas" are specified within an image frame: the VANC with a SAFE VANC DATA SPACE sub-region, the HANC DATA SPACE, and the ACTIVE IMAGE AREA. The ACTIVE IMAGE AREA, which extends from the line following Line B through Line C inclusive, contains the imagery content, while the VANC and HANC are reserved for non-image data.

Within the VANC data space, the SAFE VANC DATA SPACE, as defined by the specific format standard is an area considered "safe" for inserting non-image data; this is indicated by

Lines A through Line B. SMPTE RP 168 [5] defines a switching point area within the format considered unreliable to insert data. The line designated for the switching point is chosen to be after the vertical synchronization information (to minimize the possibility of disturbances to this information), but early in the vertical interval space. This ensures that data (time information, audio, etc.) transmitted during the VANC remains with the image frame with which it is associated. RP 168 recommends that vital ancillary data or payload data be excluded from the line following the switching line.

Table 3 indicates the values for Line A and Line B which bound the SAFE VANC DATA SPACE for two image formats, as well as the lines designated for timestamps (Precision Time Stamp Pack, Nano Precision Time Stamp Pack and Commercial Time Stamp). The available safe lines per frame within the VANC where metadata and other data can be safely inserted are computed as Line B – Line A + 1.

Table 3: Available Scan Lines for ANC Packets (single link interfaces)

Image Format	SAFE VANC DATA SPACE		Lines Designated for Timestamps	Available Safe Lines per Frame
	Line A	Line B		
480p	11	39[1]	Line 9 = Precision Time Stamp Pack or Nano Precision Time Stamp Pack Line 14 = Commercial Time Stamp	29
576p	7	44	Line 9 = Precision Time Stamp Pack or Nano Precision Time Stamp Pack Line 14 = Commercial Time Stamp	38
720p	8	25	Line 9 = Precision Time Stamp Pack or Nano Precision Time Stamp Pack Line 14 = Commercial Time Stamp	18
1080p	8	41	Line 9 = Precision Time Stamp Pack or Nano Precision Time Stamp Pack Line 14 = Commercial Time Stamp	34

[1]The 480p vertical interval persists through Line 42; SMPTE RP 214 [6] recommends a limit of 3 lines earlier.

10.2 KLV Metadata

KLV metadata is encapsulated as an Ancillary (ANC) packet in primarily the VANC (see Figure 3), and secondarily the HANC. SMPTE ST 291-1 [7] specifies the format for ANC packets inserted into either the VANC or the HANC. An ANC packet begins with a preamble called the Ancillary Data Flag (ADF), which is a three-value 10-bit word sequence of 0x000 (ADF-1), 0x3FF (ADF-2), and 0x3FF (ADF-3) as shown in Figure 4.

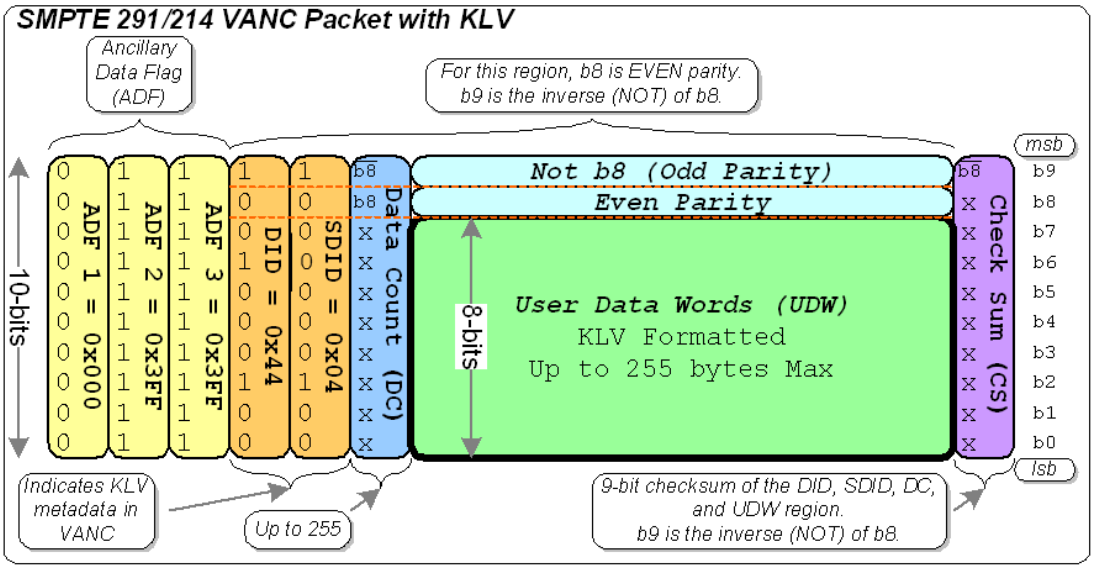

Figure 4: ANC Packet with KLV

Each ANC packet carries a Type 1 or Type 2 Data Identification (DID) word, which are registered with SMPTE; these signal the type and format of the data contained in the packet. ST 0605 uses SMPTE ST 291-1 Type 2 packets. SMPTE RP 214 [6] defines DID = 0x44 for KLV encoded data, while the Secondary DID word (SDID) signals the use of the VANC (SDID = 0x04) or HANC (SDID = 0x14). The Data Count (DC) represents the number of User Data Words (UDW) in an ANC packet, which has a maximum value of 255.

The DID, SDID, DC, and the UDW's within an ANC packet are 10-bit values. Bit 8 (b8) is used to indicate even parity, while bit 9 (b9) = NOT b8 indicates its inverse.

10.2.1 User Data Words (UDW) formatting for KLV data

The UDW space of an ANC packet formatted to carry KLV data is shown in Figure 5. SMPTE RP 214 [6] specifies a method for inserting KLV-formatted data into ANC packets. It describes the packaging of 8-bit data within the 10-bit UDW space of an ANC packet, a Message ID (MID) field, and a Packet Sequence Count (PSC).

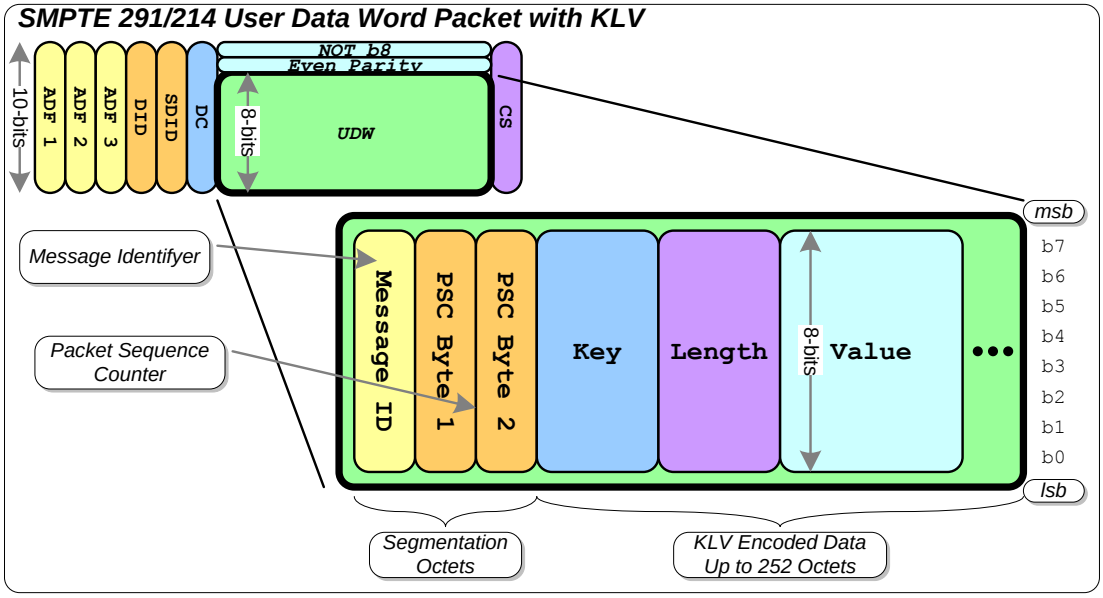

Figure 5: User Data Word space carrying KLV data

The first three words of the UDW space are mandatory per SMPTE RP 214:

- The first word of the UDW space is a Message ID (MID) field, which identifies ANC packets as belonging to the same KLV message.
- The next two words of the UDW space represent a Packet Sequence Counter (PSC), which links long KLV messages to one another.

The 255-3=252 bytes balance are available for KLV data payload within each ANC packet:

- The balance of the UDW space is for KLV data (up to 252 bytes). Over a digital interface, bit 8 of a KLV UDW is the even parity of bits 0 through 7, and bit 9 is the logical NOT of bit 8.

Requirement	
ST 0605.4-02	KLV Metadata shall be formatted in accordance with SMPTE RP 214 [6].

10.2.1.1 Message ID (MID) Information

In SMPTE RP 214, the MID value identifies ANC packets carrying information belonging to the same KLV encoded message. The MID increments with each different message from one (1) to 255 (zero is not supported) with each KLV message sent within the ANC space.

Note: The initial release of this document (RP 0605 Aug 2006) recommended using the MID field to convey additional information about the type of KLV data contained in the ANC packet. This older method allowed the same MID to be for multiple different KLV packets each falling into a common group (i.e. “Geospatial / Security Data” had a MID of 0x01). When a second KLV packet is identified with the same MID value as a previous packet, the PSC is then repeated. Downstream systems then ignore the second set of KLV

packets as they have identical MID and PSC values as previous packets. This practice is no longer recommended (deprecated in RP 0605.2 May 2008).

Requirement	
ST 0605.4-04	The practices for identifying Message ID (MID) values shall be in accordance with SMPTE RP 214 [6].

10.2.1.2 Packet Sequence Count (PSC) Information

KLV encoded messages may be comprised of multiple ANC packets. The two UDWs following the MID field represent a packet sequence count (PSC). The PSC – a 16-bit number – indicates the ANC packet for the KLV encoded message. The first data word of the PSC represents the upper 8 bits and the second data word represents the lower 8 bits of the 16-bit number (bit 7 of the first word represents the MSB, while bit 0 of the second word represents the LSB of the PSC value).

The first ANC packet for each different MID has a PSC value starting at one (1), and increments by one (1) for each successive VANC KLV packet carrying a KLV packet. KLV data is removed beginning with the ANC packet with PSC = 1.

10.2.2 Inserting the Precision Time Stamp Pack into the VANC

Requirement(s)	
ST 0605.8-23	Where a Precision Time Stamp Pack is used, the Precision Time Stamp Pack shall be present in a SMPTE RP 214 [6] packet in the VANC data space of every Motion Imagery frame.
ST 0605.8-24	Where a Precision Time Stamp Pack is used, the Precision Time Stamp Pack shall be the first SMPTE ST 291-1 [7] ANC packet on Line 9 of the Motion Imagery frame.

As some systems may benefit from additional information on the quality of the timestamp, it is recommended a Time Transfer Local Set, as defined in MISB ST 1603, be inserted following the Precision Time Stamp Pack.

Additional ANC packets may follow the Precision Time Stamp Pack.

10.2.3 Inserting the Nano Precision Time Stamp Pack into the VANC

Requirement(s)	
ST 0605.8-25	Where a Nano Precision Time Stamp Pack is used, the Nano Precision Time Stamp Pack shall be present in a SMPTE RP 214 [6] packet in the VANC data space of every Motion Imagery frame.
ST 0605.8-26	Where a Nano Precision Time Stamp Pack is used, the Nano Precision Time Stamp Pack shall be the first SMPTE ST 291-1 [7] ANC packet on Line 9 of the Motion Imagery frame.

Since some systems may benefit from additional information on the quality of the timestamp, it is recommended a Time Transfer Local Set, as defined in MISB ST 1603, be inserted following the Nano Precision Time Stamp Pack.

Additional ANC packets may follow the Nano Precision Time Stamp Pack.

10.2.4 Commercial Time Stamp

To improve interoperability with commercial equipment, a Commercial Time Stamp as defined in MISB ST 0603 may be inserted into each Motion Imagery frame. The Commercial Time Stamp is formatted into a SMPTE ST 291-1 ANC packet (called Ancillary Time Code or ATC) per SMPTE ST 12-2 [8].

Requirement(s)	
ST 0605.4-11	When available a Commercial Time Stamp shall be inserted in the VANC of every Motion Imagery frame.
ST 0605.5-16	When present, the Commercial Time Stamp shall be the only SMPTE ST 291-1 [7] packet on Line 14 of the Motion Imagery frame.

It is recommended that no other data be placed onto Line 14 other than the Commercial Time Stamp.

10.3 Motion Imagery Payload Identifier

SMPTE ST 424 [9] relies on SMPTE ST 425 [10] for identifying the source image format conveyed over a SDI physical interface. SMPTE ST 425 mandates that a Payload Identifier (specified by SMPTE ST 352 [11]) be included in the HANC.

10.4 Guidelines for Data Placement

Image formats allow various color models; for example, a color model based on R'G'B' tristimulus values, or a color model based on Luma and Chroma values (e.g. $Y'C'_bC'_r$). When using a Luma/Chroma color model, metadata is inserted into the Luma space first followed by use of the Chroma space. For example, Line 9 Luma data, Line 10 Luma data … Line B Luma data, followed by Line 9 Chroma data, Line 10 Chroma data … etc.

Requirement(s)	
ST 0605.4-03	The Luma data space within the VANC shall be used for KLV data prior to using the Chroma data space.
ST 0605.4-15	When inserting ANC packets containing non-KLV data into the VANC, those packets shall follow all ANC packets containing KLV data.
ST 0605.5-17	KLV data shall be inserted into the VANC only in the SAFE VANC DATA SPACE as specified in MISB ST 0605 Table 3.

10.5 Audio Encoding in AES3

The Horizontal Ancillary Data Space (HANC) is principally used to carry digital audio. SMPTE ST 299-1 [12] (16 audio channels) and SMPTE ST 229-2 [13] (32 audio channels) defines the mapping of 24-bit AES3 (Digital Audio Interface Format) digital audio data into the ancillary data space as ANC packets. The formatting of non-PCM audio and other data, such as metadata, to AES3 is defined by SMPTE ST 355 [14], SMPTE ST 337 [15], and SMPTE ST 339 [16].

Audio carriage in SDI is well described in these standards, so no further information is provided here.

Requirement	
ST 0605.5-18	KLV data encapsulated in an AES3 serial digital audio stream shall comply with SMPTE ST 299-1 [12] and SMPTE ST 299-2 [13] with data formatted according to SMPTE ST 355 [14], SMPTE ST 337 [15] and SMPTE ST 339 [16].

11 Deprecated Requirements

Requirement(s)	
ST 0605.4-01 (Deprecated)	The Precision Time Stamp, Commercial Time Stamp and KLV Metadata shall be inserted into the Vertical Ancillary Data Space (VANC). [Redundant: covered by REQ's 5 &11]
ST 0605.4-05 (Deprecated)	A Precision Time Stamp Pack representing Coordinated Universal Time (UTC) for the start of a Motion Imagery frame shall be present in a SMPTE RP 214 [6] packet in the VANC data space of every Motion Imagery frame. [Precision Time Stamp based on count since Epoch, not UTC]
ST 0605.4-06 (Deprecated)	The Precision Time Stamp Pack shall contain the Key (in hex) 06.0E.2B.34.02.05.01.01.0E.01.01.03.11.00.00.00 (CRC 23259). [defined in ST 0807, so no requirement necessary]
ST 0605.4-12 (Deprecated)	When present, the Commercial Time Stamp shall be the first SMPTE ST 291-1 [7] packet on Line 14 of the Motion Imagery frame. [changed "first" to "only" as recommended by SMPTE]
ST 0605.4-13 (Deprecated)	KLV data shall be allowed to be inserted into the VANC on Line 15 and above. Non-KLV data is allowed on line 14 after the Commercial Time Stamp. [VANC is not limited to KLV; non-image data allowed in safe VANC data space]
ST 0605.4-14 (Deprecated)	The insertion of KLV data in a frame shall discontinue once the end of the VANC is reached [states an obvious fact and should not be a requirement]
ST 0605.7-19 (Deprecated)	A Precision Time Stamp Pack shall be present in a SMPTE RP 214 [6] packet in the VANC data space of every Motion Imagery frame.
ST 0605.4-10 (Deprecated)	The Precision Time Stamp Pack shall be the first SMPTE ST 291-1 [7] ANC packet on Line 9 of the Motion Imagery frame.

12 Appendix A: Example VANC Capacities – *Informative*

The following calculations approximate the VANC capacity for various digital image formats.

SMPTE ST 291-1 [7] specifies the format of an ANC packet. A packet contains 10-bytes of overhead (3-bytes ADF, 1-byte DID, 1-byte SDID, 1-byte DC, 1-byte MID, 2-byte PSC, 1-byte CS) with a maximum of 252 bytes available for data. Thus, each ANC packet has a maximum of 262 bytes. Metadata capacity calculated for Extended Definition 480p, 576p, and High Definition 720p, 1080p systems is shown in Table 4 . For each Image Format, the number of ANC Packets (full) per VANC Line along with the VANC Safe Lines provides the number of Bytes per Frame, which corresponds to a computed Data Rate for 60 Frames per Second (FPS).

Table 4: VANC Capacity for Full ANC Packets

Image Format	Samples per Line	ANC Packets (full) per VANC Line	VANC Safe Lines[3] (Table 3)	Bytes per Frame	Data Rate (60 FPS) (Mbps)
480p	720	2	58	29,232	14.03
576p	720	2	76	38,304	18.38
720p	1280	4	36	36,288	17.41
1080p	1920	7	68	119,952	57.57

[3]Assuming an equal number of lines for Luma and Chroma the number of VANC Safe Lines is twice that specified in Table 3.

A full ANC packet can contain 262 bytes. The maximum number of ANC packets when full per VANC Line is computed by the number of Samples per Line divided by 262 bytes. From Table 3, and assuming a color model of 4:2:2, the Bytes per Frame is the product of the number of ANC Packets times the number of VANC Safe Lines times 262 bytes. Data Rate, expressed in megabits per second, for 60 frames per second (FPS) is then the number of Bytes per Frame times 8 bits per Byte times 60 FPS.

These calculations ignore partial packets, which would increase the data rate, and do not account for the requirements on Lines 9 and 14 indicated in this document.

13 Appendix B: SDI (Serial Digital Interface) - *Informative*

The SMPTE suite of SDI standards provides the physical interface, timing, encoding, payload and image formats for digital video. SDI standardizes the transport of non-compressed low latency video over a wide range of image formats, and in addition, provides for the carriage of non-imagery data, such as metadata located in the Vertical Ancillary Data Space (VANC) and the Horizontal Ancillary Data Space (HANC). Both the VANC and HANC are available on a per-frame basis, affording non-image data to be registered to a specific frame in Motion Imagery. This facilitates inserting frame-accurate timestamps and other metadata into non-compressed Class 0 Motion Imagery. For 2160p UHD1 the mapping of ancillary data into 3G-SDI, 6G-SDI and 12G-SDI follow the guidelines for 1080p, which prescribes a decomposition of UHD into sub-images equivalent to 1080p (See Appendix D).

14 Appendix C: SMPTE Standards: Formats/Interfaces

The SMPTE standards for various Image Formats and the supporting SDI standard(s) are listed in Table 5. Also, shown is the number of Active Pixels per Line, Active Lines per Frame and the supported Frame Rate(s). Note that only common frame rates are listed. Please consult the relevant standard for a complete list of supported frame rates.

Table 5: Image Format Standards and Companion SDI Standards

Image Format	Format Standard	SDI Standard	Active Pixels per Line	Active Lines per Frame	Frame Rate
Enhanced Definition (progressive line Standard Definition)					
480p	SMPTE ST 267 [17] SMPTE ST 294 [18]	SMPTE ST 259 [19] (Level D 4:2:0)	720	483	60M[2]
480p	SMPTE ST 293 [20]	SMPTE ST 349 [21] SMPTE ST 292-1 [22]	720	483	60M/30M
576p	ITU-R BT.1358 [23]	SMPTE ST 349 [21] SMPTE ST 292-1 [22]	720	576	50/25
High Definition (HD-SDI)					
720p	SMPTE ST 296 [24]	SMPTE ST 292-1 [22]	1280	720	60/50/30/25
1080p	SMPTE ST 274 [25]		1920	1080	30/25
High Definition (3G-SDI)					
1080p	SMPTE ST 425-1 [10]	SMPTE ST 424 [9]	1920	1080	60/50/30/25
Ultra-High Definition (10G-SDI)					
2160p	SMPTE ST 435-1 [26] SMPTE 2036-1 [27]	SMPTE ST 435-2 [28] SMPTE ST 2036-3 [29]	3840	2160	120/60/50/30/25
4320p			7680	4320	

[2] M = 1000/1001

15 Appendix D: Ultra-High Definition (UHD 1) – *Informative*

The current roadmap for UHD, which includes UHD1 and UHD2, divides a UHD image into HD (1080p) sub-images – 4 for UHD1 and 16 for UHD2. Each sub-image has timing, audio, and data, etc. added just like HD. The sub-images are then multiplexed as necessary for transport. For UHD1, the sub-images are combined into a single-link 12G-SDI (SMPTE ST 2082-10 [30]), dual-link 6G-SDI (SMPTE ST 2081-11 [31]), or quad-link 3G-SDI (SMPTE ST 425-5 [32]) for transport as shown in Figure 6. Payload identifiers are required to indicate the specific 1080p component image. 1080p components are mapped as channels (i.e. CH1 - CH8). SMPTE requires that ANC data be mapped into CH1. ANC data inserted into the VANC follows the same rules as the 1080p format.

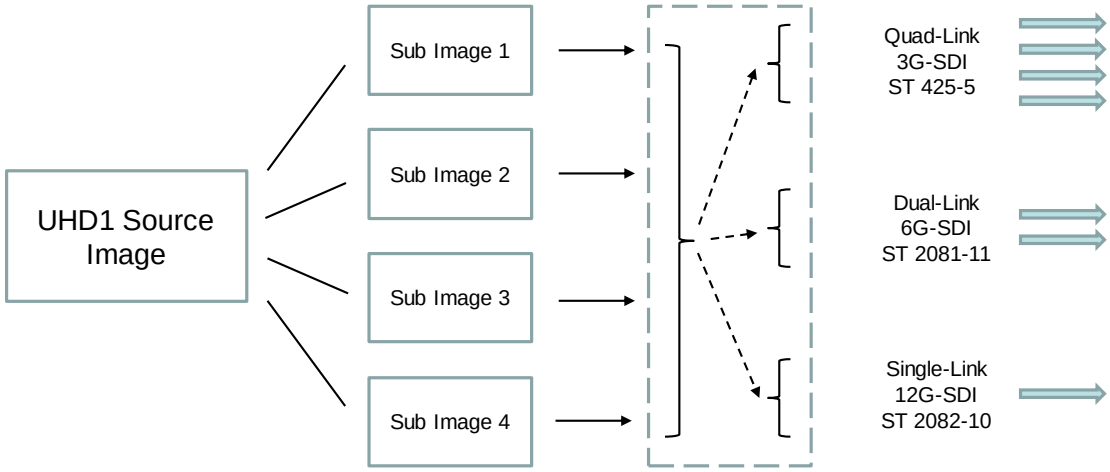

Figure 6: UHD 1 Transport over 3G/6G/12G SDI

16 Appendix E: Image Format, Data Rate, SDI Type – *Informative*

Table 6 lists computed data rates for various HD and UHD 1 Motion Imagery formats and those SDI containers which support a specific data rate. In computing the data rate, a 4% overhead for metadata per image frame is included. Single link SDI is assumed.

Table 6: SDI Type to Support Motion Imagery Data Rate

	Motion Imagery Format	Data Rate (Gbps)	HD-SDI 1.458 Gbps	3G-SDI 2.97 Gbps	6G-SDI 5.94 Gbps	12G-SDI 11.88 Gbps
HD	8-bit 4:2:2 1080p30	0.96	3	3	3	3
	8-bit 4:4:4 1080p30	1.45	3	3	3	3
	10-bit 4:2:2 1080p30	1.21	3	3	3	3
	10-bit 4:4:4 1080p30	1.81		3	3	3
	8-bit 4:2:2 1080p60	1.93		3	3	3
	8-bit 4:4:4 1080p60	2.89		3	3	3
	10-bit 4:2:2 1080p60	2.41		3	3	3
	10-bit 4:4:4 1080p60	3.62			3	3
UHD 1	8-bit 4:2:2 2160p30	3.86			3	3
	8-bit 4:4:4 2160p30	5.79			3	3
	10-bit 4:2:2 2160p30	4.82			3	3
	10-bit 4:4:4 2160p30	7.23				3
	8-bit 4:2:2 2160p60	7.72				3
	8-bit 4:4:4 2160p60	11.57				3
	10-bit 4:2:2 2160p60	9.65				3
	10-bit 4:4:4 2160p60	14.46				

Data Rate = Image HV sample density x color factor x metadata factor x frame rate / SF; where, color factor = (Y+Cr+Cb)/12 * color bit depth * 3; metadata factor = 1.04 (4%); SF = 1024x1024x1024